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Tiller Contributions to Low-Density Corn Biomass and Yield

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Tiller Contributions to Low-Density Corn Biomass and Yield

Abstract

Tillers (commonly termed "suckers") have lower overall yield contributions in corn (*Zea mays* L.) than in other Poaceae species. Current research evaluating the value of tillers in corn is scarce, particularly under water-limited conditions. This study aims to quantify relationships between tiller, main plant, and full (considering both tiller and main plant fractions) plant aboveground biomass and yields of corn under low plant density scenarios. Experiments were conducted in the 2019 growing season at three sites across Kansas (Garden City, Goodland, and Manhattan) evaluating two tiller-prone corn hybrids common in this region (P0805AM and P0657AM) at two plant densities (10,000 and 17,000 plants/a) with tiller maintenance (YT) or tiller removal (NT) at the V10 growth stage (tenth leaf). Treatments were set in a split-split-plot under a randomized complete block design (RCBD) with three replications. Results showed that full shoot dry biomass at maturity was neutrally or positively influenced by both tiller presence and an increase in plant density. Although yield from ears on the main plant (herein termed as "main plant yields") can be negatively impacted by tillers, full yield of all portions of the plant (herein "full plant yields") were neutrally or positively influenced by tiller contributions. Tiller yield variation in this study was influenced by tiller reproductive development, specifically tassel and lateral ear types. Responsible mechanisms and environmental factors influencing these development processes remain largely unknown, and this will be the focus of continuing studies.

Keywords

corn, tiller, plant density, yield, biomass

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Tiller Contributions to Low-Density Corn Biomass and Yield

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Summary

Tillers (commonly termed "suckers") have lower overall yield contributions in corn (*Zea mays* L.) than in other Poaceae species. Current research evaluating the value of tillers in corn is scarce, particularly under water-limited conditions. This study aims to quantify relationships between tiller, main plant, and full (considering both tiller and main plant fractions) plant aboveground biomass and yields of corn under low plant density scenarios. Experiments were conducted in the 2019 growing season at three sites across Kansas (Garden City, Goodland, and Manhattan) evaluating two tiller-prone corn hybrids common in this region (P0805AM and P0657AM) at two plant densities (10,000 and 17,000 plants/a) with tiller maintenance (YT) or tiller removal (NT) at the V10 growth stage (tenth leaf). Treatments were set in a split-split-plot under a randomized complete block design (RCBD) with three replications. Results showed that full shoot dry biomass at maturity was neutrally or positively influenced by both tiller presence and an increase in plant density. Although yield from ears on the main plant (herein termed as "main plant yields") can be negatively impacted by tillers, full yield of all portions of the plant (herein "full plant yields") were neutrally or positively influenced by tiller contributions. Tiller yield variation in this study was influenced by tiller reproductive development, specifically tassel and lateral ear types. Responsible mechanisms and environmental factors influencing these development processes remain largely unknown, and this will be the focus of continuing studies.

Introduction

Tillering is a genetically influenced environmental plasticity response that has historically been under great debate among corn producers, agronomists, and researchers. Tillers (commonly "suckers") are induced by favorable environmental conditions in cereals, but due to relatively late development of tillers in corn, overall productivity contributions are less than in other Poaceae species. Current research evaluating the overall value of tillers to corn plant productivity is scarce, particularly under water-limited conditions. Because corn planted in water-limited or dryland environments, specifically in western Kansas, is commonly intended for final stands less than 20,000 plants/a, conditions are prime for tiller development given the use of conducive hybrids. Of particular interest in corn is the effect that tillers have on productivity of the main stalk (thus their nickname, "suckers"). Fact-based conclusions regarding tillering implications in modern corn hybrids are elusive. For this reason, the objective

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of this study was to quantify relationships between tiller, main plant, and full plant aboveground biomass and yields of corn under low plant density scenarios.

Procedures

Data discussed here were gathered in the first year (2019) of a multi-year study conducted across the state of Kansas, at experimental field locations at the Ashland Bottoms Research Farm, Manhattan, KS (39.143°N, -96.639°W); Corteva Agriscience Research and Development Center, Garden City, KS (37.827°N, -100.857°W); and a Corteva Agriscience yield test AOI (Area of Interest), Goodland, KS (39.249°N, -101.782°W). Garden City and Goodland were maintained under limited irrigation, and Ashland Bottoms was a true dryland location. All plots were fertilized as necessary to avoid any deficiencies and maintained with appropriate pesticides. Eight-row plots were planted at 30-in. row spacing, with final dimensions of 20-ft wide × 30-ft long at Ashland Bottoms, and 20-ft wide × 17.4-ft long in Garden City and Goodland.

Plots were arranged in a split-split plot design, with three factors evaluated: planting density with two levels in the main plot, genotype with two levels in the sub-plot, and tiller treatment with two levels in the sub-sub-plot. For both levels of plant density [low (10,000 plants/a) and average (17,000 plants/a)], two Pioneer corn hybrids common in the selected region (P0805AM and P0657AM), and two tiller treatments [removal (NT) or maintenance (YT) of tillers present at phenological stage V10, as shown in Figure 1] were evaluated.

Measurements throughout the growing season included phenology; stand counts; tiller counts; partitioned dry shoot biomass at set phenological stages of fifth-leaf (V5), tenth-leaf (V10), pre-flowering (V16), reproductive milk stage (R3), and physiological maturity (R6); ear characterization counts; and partitioned grain yields. Partitioned shoot biomass was calculated by dividing aboveground dry biomass by component (tiller and main plant). Ear characterization counts were conducted at harvest, and accounted for the percentage of ears in a plot that belonged to each of three determined categories – main plant lateral ears (productive), tiller lateral ears (productive), and tiller apical ears (commonly "tassel ears," unproductive), as shown in Figure 2. Final yields were also partitioned by ear type.

Our selected organization structure allowed for direct comparison and quantification of the effect of corn tillers on both the full plant and the main plant. Data were classified in all cases into the following three partitions: full plant (main + tillers), main plant (main only), and tiller (tillers only). In addition, due to differences in yield goals, environmental conditions, and responses observed among sites, each experimental location was analyzed separately. Analysis of variance (ANOVA) was performed to determine the significance of nested factors in the experimental design with regard to both final biomass measurements and harvest data. All statistical analysis was performed with R software.

Results

Mature Aboveground Biomass

While season-long biomass dynamics were measured, only R6 dry shoot biomass (measured at harvest) will be discussed in this report for the sake of simplicity. Mature biomass contributions by partition and location are shown in Figure 3.

Full plant dry biomass at Ashland Bottoms was similar when comparing the plots planted to the highest density with the plots containing intact tillers. Because main plant biomass was only affected by plant density, tillers had the same effect as a higher density on full plant biomass.

Main plant dry biomass values were significantly influenced by tiller presence in Garden City, which would be expected considering the added competition for resources. However, full plant and tiller biomass were not different considering any treatment in Garden City. That is, tillers had a completely neutral, balancing effect on full biomass in this location.

Biomass results in Goodland ultimately told the same story. Main biomass values were influenced by specific interactions of factors, resulting in significance only for one treatment with regard to hybrid (H), two treatments with regard to density (D), and two with regard to tiller (T) treatment. Although tiller biomass was stable across treatments, full biomass again experienced a balancing effect, resulting in no treatment difference when comparing D or T individually.

Final Grain Yield

Full grain yields partitioned by ear type are shown in Figure 4. Locations ordered by lowest to highest yield potential were as follows: Ashland Bottoms (100 bu/a), Garden City (150 bu/a), and Goodland (180 bu/a). Contributions from both tiller tassel ears and tiller lateral ears to full yields were different in all locations, with Garden City having the greatest yield from tiller tassel ears and Goodland having the greatest yield from tiller lateral ears. These contributions affected the significance of full yield differences between treatments.

Final yields at Ashland Bottoms were significantly lower in the 10,000 plants/a density for only one of the hybrids (P0805AM at 68 bu/a). The P0805AM hybrid yielded 94 bu/a at the 17,000 plants/a density, and the P0657AM hybrid yielded 92 bu/a and 86 bu/a for the 10,000 and 17,000 plants/a densities, respectively. In this regard, the presence of tillers had no effect on yields in this location.

Garden City full yields were not significantly different from each other considering any of the individual treatments applied. Plots without tillers (NT) yielded 144 bu/a and 160 bu/a for the 10,000 and 17,000 plants/a densities, respectively. Plots with tillers (YT) yielded 140 bu/a and 150 bu/a for the 10,000 and 17,000 plants/a densities, respectively. All treatment factors considered, tillers had a neutral effect on yields in this location also.

Considering full yields in Goodland, the only value significantly different from its counterparts was the lowest density without tillers, which yielded 152 bu/a. The 10,000 plants/a density with tillers (YT) yielded 173 bu/a, while the 17,000 plants/a density yielded 186 bu/a and 190 bu/a for plots without (NT) and with (YT) tillers, respectively. In this regard, plots with tillers (YT) were able to produce yields similar to those of plots with a 68% greater plant density (see Figure 5). Tillers in the higher plant density had no effect on final yield.

Ear Development Yield Impacts

To better understand tiller yield contributions, characterization of ear types was warranted. Results of ANOVA tests revealed that tiller ear counts were only significantly influenced by density ($P \le 0.05$), and specifically in the Goodland location. Ear type characterization percentages for plots with maintained tillers (YT) are shown in Figure 6.

Of the total ears produced by plots at Ashland Bottoms, 25% and 4% were classified as tiller tassel (apical) ears in the low and average densities, respectively; 7% and 1% were classified as tiller lateral ears in the low and average densities, respectively.

Of the total ears produced in Garden City plots, 29% and 11% were classified as tiller tassel (apical ears) for the low and average densities, respectively; 13% and 6% were classified as tiller lateral ears for the low and average densities, respectively.

Of the total ears produced by plots in Goodland, less than 1% were classified as tiller tassel (apical) ears in both the low and average densities; 35% and 10% were classified as tiller lateral ears in the low and average densities, respectively.

Considering all locations and densities, Goodland plots planted at 10,000 plants/a produced the greatest percentage of tiller lateral ears (35% of total ears harvested), and Garden City plots planted at 10,000 plants/a produced the greatest percentage of tiller apical ears (29% of total ears harvested).

Figure 1. Images demonstrating tiller biomass at time of removal (V10, tenth leaf). Right panel shows plot with tillers intact (YT). Left panel shows plot with tillers removed (NT).

Figure 2. Images illustrating difference in tiller ear development at low densities. Right panel shows a prolific main stalk with a productive, lateral ear-bearing tiller. Left panel shows multiple plants with tillers developing undesirable "tassel ears."

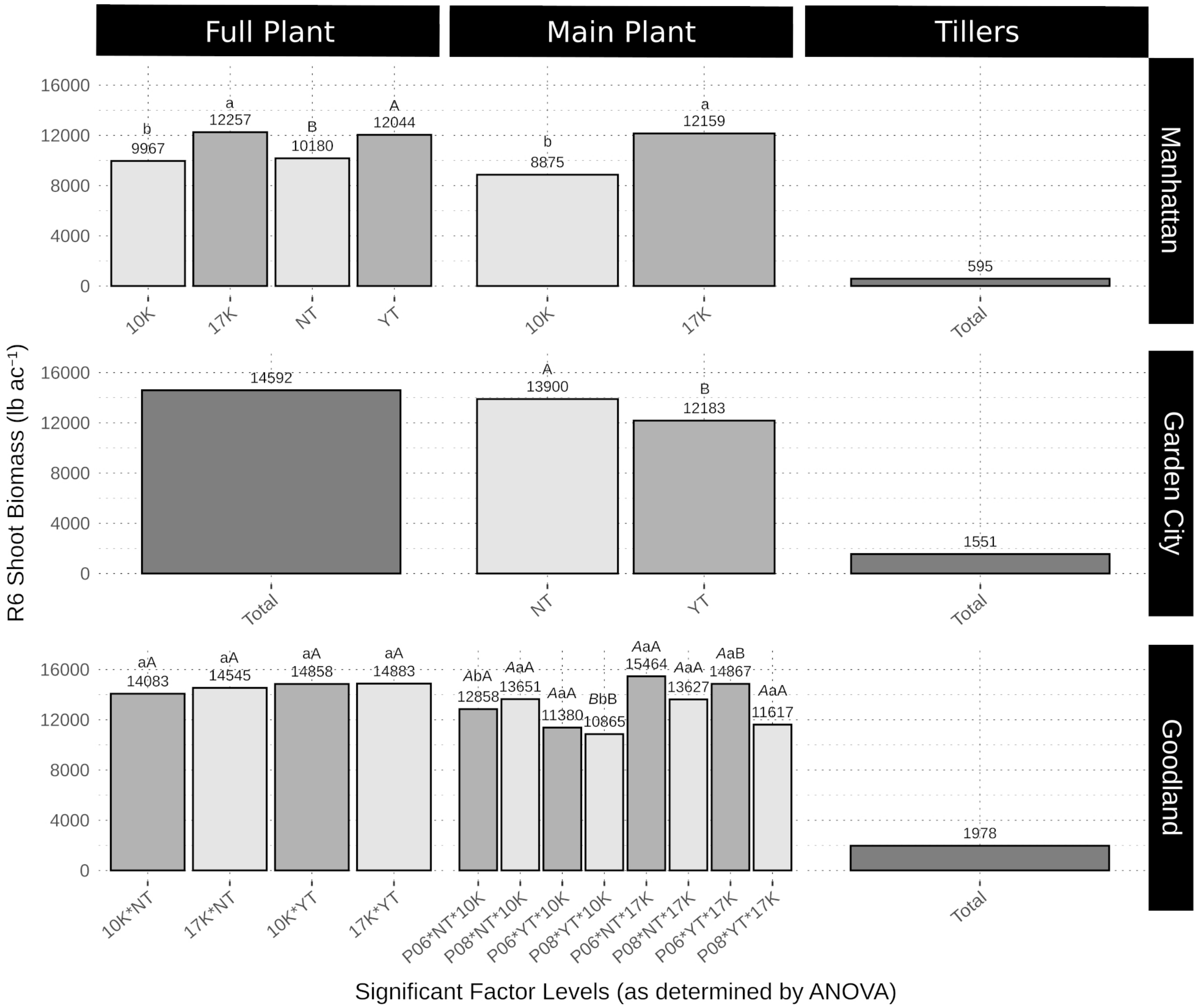

Figure 3. Mean R6 dry shoot biomass and mean comparisons (Tukey) for each factor level deemed significant by ANOVA tests considering each partition and location separately. (Lowercase letters used to compare densities at a given factor level; uppercase letters used to compare tiller treatments at a given factor level; uppercase italic letters used to compare hybrids at a given factor level.)

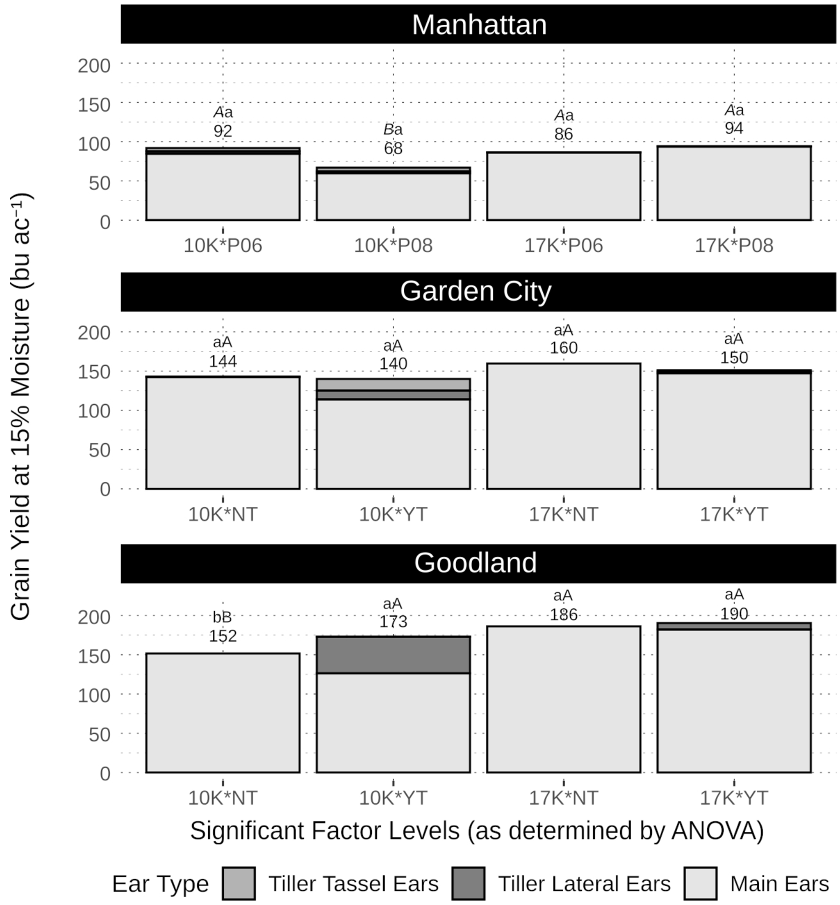

Figure 4. Mean full grain yields (15% moisture) and mean comparisons (Tukey) for each factor level deemed significant by ANOVA tests considering each partition and location separately. (Lowercase letters used to compare densities at a given factor level; uppercase letters used to compare tiller treatments at a given factor level; uppercase italic letters used to compare hybrids at a given factor level.)

Figure 5. Images demonstrating yield potential of corn tillers in different densities. Right panel shows prolific main stalk with two productive tillers in a 10,000 plants/a population. Left panel shows a main stalk with two productive tillers in a 17,000 plants/a population.

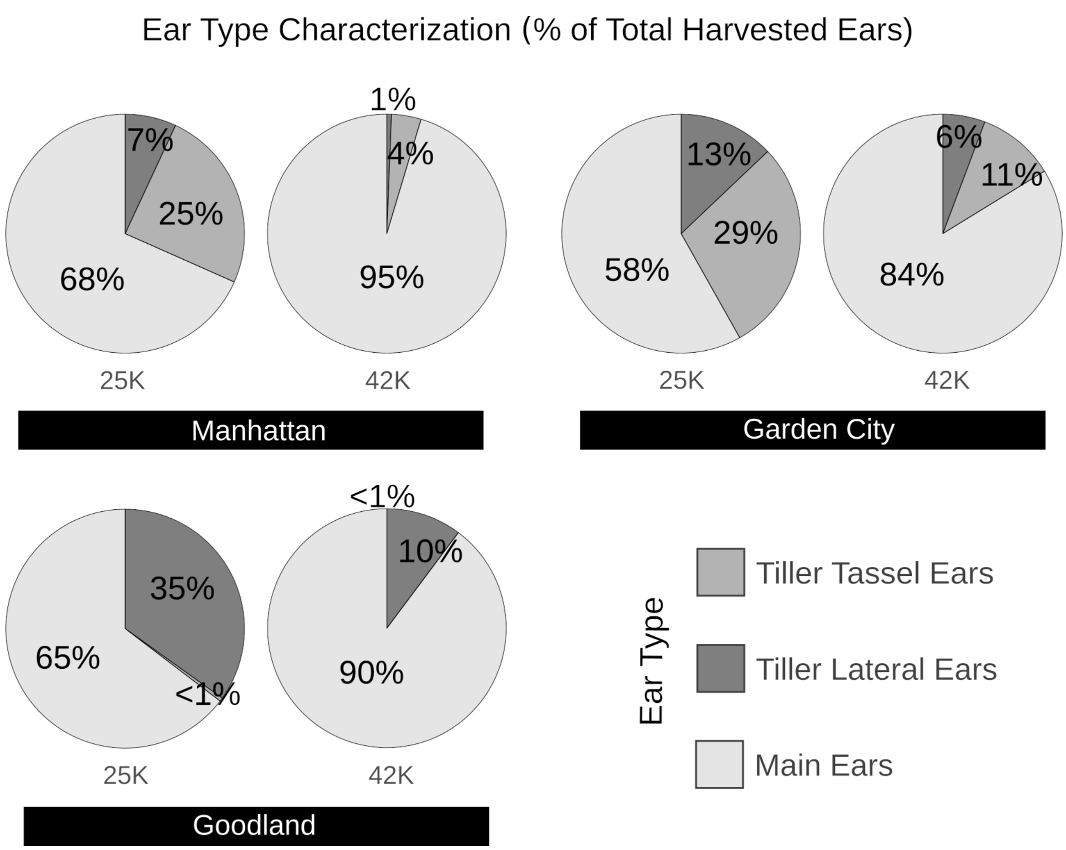

Figure 6. Characterization of ear types by density within location (only level deemed significant by ANOVA tests). Each ear type shown by percentage of total harvested ear count. Only YT plots (*maintained tillers*) were considered.